Hazardous Liquids Airborne Lidar Observation Study (HALOS)

Quarterly Status and Progress Report
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In this project, with support of DOT/PHMSA, ITT Industries intends to extend its current Airborne Natural Gas Emission Lidar (ANGEL) technology to create a conceptual design for an airborne hazardous liquid leak detection system. The major deliverable for this phase of the study is the "Simulated Leak Test Report". This report consists of five distinct sections: Processed Data from Existing Sensor and Findings; Overview of Software Modifications; Overview of Hazardous Liquids Pipelines; Spectral Characteristics of the Target; and Plume Characteristics. An overview of each of these sections follows.

Processed Data from Existing Sensor and Findings

In the months of June and July the ANGEL sensor was used to collect HALOS data at three different locations in New York and Texas. These collects consisted of 1) overflights over natural gas and light crude oil vapor releases at an El Paso Gas Facility in Kingsville, TX, 2) overflight of propane, gasoline, and diesel fuel releases in Corpus Christi in cooperation with researchers at Texas A&M University in Corpus Christi, TX, and 3) overflights of a series of staged propane releases on the town of Spencerport, NY. Initial review of the data is extremely encouraging and shows we were able to use ANGEL to detect hydrocarbons other than methane at all three sites. Data analysis is ongoing and will be performed in concert with the development of the HALOS algorithms. Additional future activities will include calibration activities at a test range in Dansville, NY and possible additional ANGEL overflights over a variety of additional staged leaks.

Overview of Software Modifications

Based on preliminary knowledge of the physical and spectral properties of the hazardous liquid target plumes. Work has begun on a series of algorithmic approaches which will allow the analysis of data from the unmodified ANGEL sensor. The simplest algorithm labeled the Zeroth Order Algorithm will be to make no changes to the current processing. As designed, propane and gasoline in large enough concentrations are likely to produce large negative methane Concentration Path Length (CPL) values with the existing ANGEL data processing scheme. A future First Order Algorithm is described in this report. The proposed First Order Algorithm will use all three ANGEL spectral lines and will use a multispectral analysis of the data (rather than differential absorption) in which test data is compared to known target spectral signatures to identify hazardous liquids

signatures in a stream of data. For the purpose of this study the algorithm will be coded as an engineering prototype and will be run by hand on small data sets extracted from ANGEL test sets. Test sets will include both ANGEL overflight data and controlled ANGEL calibration data sets collected from a stationary aircraft.

Overview of Hazardous Liquids Pipelines.

This portion of the HALOS project is in progress. Major accomplishment during the most recent period of performance was a GC mass spec analysis of gasoline and the subsequent identification of the 5 most likely major components of the early vapor plumes. It was found that although gasoline has more than 60 individual components, N–Pentane and I-Pentane dominated the vapors released from a gasoline leak during the early stages of evaporation. Combining the spectra from the 5 major vapor constituents resulted in a spectrum very similar to the saturated spectrum of gasoline measured during the early phase of the HALOS study. A preliminary gasoline vapor absorption cross section has been calculated as the result of this effort. Analysis of diesel fuel vapors is ongoing and is expected to yield similar cross section over the next 2 weeks. Modeling of subsurface behavior of hazardous liquids is ongoing. Early results indicate gasoline and diesel fuel tend to stay in liquid form in the subsurface and begin to evaporate only when exposed at the surface. This suggests that modeling the evaporation of liquids from a saturated soil or a pool of gasoline or diesel fuel at the surface may provide the most appropriate approximation of the behavior of a hazardous liquid leak in the real world.

Spectral Characteristics of the Target

Following a very successful Spring Season collect, the library of MWIR reflectance spectra has been expanded to approximately 100 target spectra. During this portion of the study the MWIR backscatter reflectance spectrometer system has been upgraded with a modified IR source which provides additional illumination. Slight negative reflectivity artifacts in some field spectra identified during the winter collects were traced to the spectrometer and corrected in the latest collect by providing additional warm-up time for the spectrometer prior to use. In addition, we have examined the spectral effect of a) specular vs. off-specular measurement angles b) soil moisture content c) organic content of soil and d) lab vs. field collects on MWIR backscatter reflectance.

Plume Characteristics

Work during this phase of the project consisted largely of planning for the upcoming physical modeling of propane, gasoline, and diesel fuel leaks previously modeled with the CHARM computational modeling program. The effort to verify numerical CHARM models will consist of physical modeling using a wind tunnel at CPP Inc. in Colorado and is currently scheduled for the next available wind tunnel time slot in the late summer. In addition to verification of the CHARM models, planned wind tunnel efforts will examine leak conditions which are difficult to accurately numerically model, including the shape and concentration of leak plumes in a heavily overgrown pipeline right-of-way and utilization of newly developed wind tunnel hydrocarbon sampling sensors to more accurately predict the turbulent shape of a gas plume.

In addition to the research leading to the creation of this report, in June Jeff Owen, Darryl Murdock and Steve Stearns visited State College, PA for a two day meeting to discuss and review the ongoing Overview of Hazardous Liquids Pipeline efforts with Dr. Russell Philbrick and the PhilCon Team. In early July, Michael Jacobs traveled to the offices of Cermak Peterka Peterson (CPP) Inc. in Ft. Collins, Colorado to plan a series of upcoming wind tunnel plume modeling verification efforts. In addition Dr. Jacobs visited an ITT AES group with experience in modeling complex 2 phase materials to discuss the modeling of gasoline and diesel fuel leaks.

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